A Humanities Based Approach to Formally Defining Information through Modelling

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Paul A. Fishwick[*]

Abstract: *»Ein geisteswissenschaftlich begründeter Ansatz zur formalen Beschreibung von Information durch Modellierung.«*. A traditional, and reasonable, way of thinking about the digital and modelling within the context of the humanities is to begin with humanistic inquiry and then explore the world of information processing and management through digital technologies, such as virtual reality, computers, smartphones, and tablets. This chain of thought revolves around the idea that information is part of the world of computing with its technological methods and marvels. However, through traditional humanities topics such as language and sensory arts, we claim that the idea of information and information processing is part and parcel of the humanistic tradition. Seeing the world as information is a matter of interpretation, and not of technologically-motivated implementation, even though such implementation provides us with efficient tools for managing information. Written and pictorial languages are a basis for formalizing information and models, independent of technology.

Keywords: Information, flow, semantic network, finite state machine.

1. Definition of Modelling

Modelling represents the activity of designing, manipulating, and testing models. We characterize three types of models that cover wide territory: knowledge, shape, and behavior. A *model of knowledge* is characterized in natural language, and can be expressed in logic or in a diagrammatic syntax (e.g., semantic networks, concept graphs, mind maps). These model forms may be augmented with multimedia in the form of static or time-varying imagery. *A model of shape* reflects the goal of using scale to make the model target more accessible, or it reflects models that capture shape and geometry of the target. A child's toy and doll house are early-age examples of scale modelling, whereas a scene graph is an example of a geometric-based model of objects comprising a scene. *A model of behavior* is a structure that captures how objects change

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state over time. A state machine, Markov chain, Petri net, and differential equations are examples of behavior models.

The simplest sorts of models have come from the humanities. If we consider the arts as divided into language arts and sensory arts, models in the language arts are formed from natural language. For example, “I am going to get the mail” contains specific parts of speech that can be linked to the formation of dynamic models. The word “going” is a gerund and was formed by taking the verb “go” and adding an “ing,” thus forming an activity. Since states within a system are captured by activities over a duration of time, “going” is a state within a state machine yet to be formulated. By parsing natural language, we can transition to ever more formally specified dynamic models. As for sensory arts, we find craft, design, and fine art. The sensory arts include all sensory modalities such as vision, sound, and touch. Visually specified states, events, and functions can be drawn or can be interpreted from a drawing.

Models can be considered to be information representations of our world – they are ways of physically encoding information using a specific technology, with associated analogies and metaphors. Consider the System Dynamics modelling framework of Jay Forrester. The flow graphs employ the analogy of flowing water that is restricted by valves, which model rates and tanks, which model capacities. System Dynamics models can be expressed using different technologies. These models can be created with purely mechanical components, hybrid mechanical-electrical components, or on the digital screen where one moves circles, rectangles, and arrows around to design the model. Therefore, the model is based on one or more analogies, and is independent of the technology used to manifest it–digital or otherwise.

2. Information Modelling within the Humanities

The humanities are a broad area encompassing the studies of human culture. Cultural artifacts that are produced consist of numerous materials that may be written or crafted. To the extent that an artifact has been produced by writing using the technology of print, this writing can be modelled in many ways. A semantic network can be drawn for a chapter in Melville’s Moby Dick, for instance. The network becomes a model of the chapter. An artist might paint a scene from the novel, with the painting serving as a model of the text capturing that scene.

Models are viewed as artifacts that we create to understand other artifacts (Fishwick 2017). Models frequently capture the information content of the artifact. The model becomes a vehicle for framing the artifact in terms of information–seeing the artifact through an information lens. This connection between the humanities and modelling differs from the classical notion within the digital arts & humanities where the “digital” is seen as a utilitarian facet for arts and humanities. We posit that the ideas behind information are situated within the humanities and so, connecting information and the humanities is less about tools, and more about reframing our understanding about the nature of information in culture.

3. Interpreting a Cultural Artifact through an Information Lens

The following exposition is reprinted from Section 3 of Fishwick (2016) describes how we may view a 500-year old Incan tunic from the standpoint of information. In this description, the tunic becomes a catalyst for a discussion of information management and processing. The role of digital technology becomes merely an accelerant of information processing rather than a tool for traditional humanistic research. The idea of information is couched in terms of a fundamentally information-specific interpretation of the tunic, rather than as a digital tool for supporting interactive exploration.

An art museum was chosen as the venue for considering systems thinking in a Fall 2015 class in Modeling and Simulation. Students were each given a choice of an object at the Dallas Museum of Art (DMA). With some guidance, they interpreted these objects through thinking of them from a systems perspective. The guidance consisted of heuristics such as: (1) represent knowledge about the objects and their representations, resulting in a concept map; (2) consider any processes or techniques associated with the object, what is represented in the object, or in the object's material; and (3) model the object with digital or physical materials. Systems thinking is atypical in an art museum, which is why it was chosen. The goal was to illustrate variety in object interpretation that ventured beyond art history explanations. Consider the Inca tunic in Figure 1, which was highlighted within a recent exhibit (DMA-Inca 2016).

Figure 1: Tunic with Checkerboard Pattern and Stepped Yoke. Courtesy of the Dallas Museum of Art, Public Digital Media Collection.

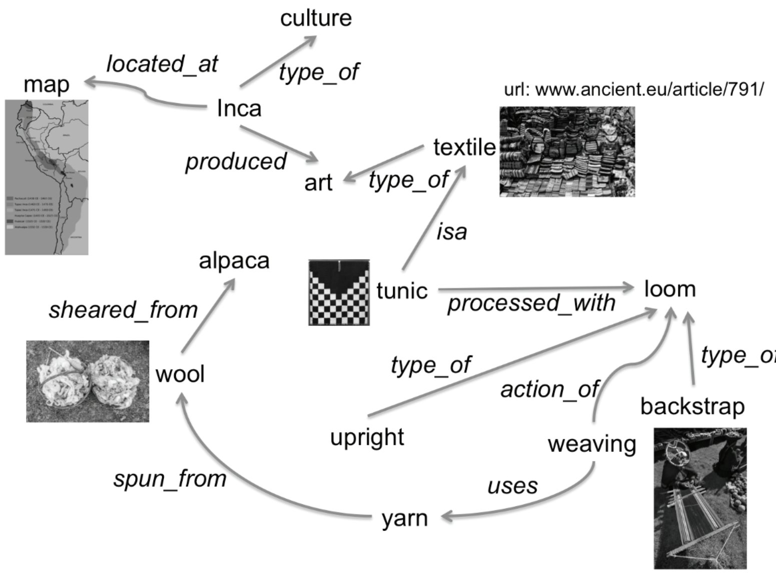
Additional Information: Inca Tunic (<https://www.dma.org/collection/artwork/pre-columbian/tunic-checkerboard-pattern-and-stepped-yoke>) (DMA-Tunic 2016).

For this tunic, there are many possible questions we may ask:

- How was the tunic originally woven?
- How would the tunic be woven today?
- Can a computer program reproduce the tunic pattern?
- How was the red fabric dyed?
- What are the population dynamics of the alpaca or llama?
- Can the colored, square motifs be used to encode information?
- What were the behaviors or rituals of the tunic wearer?
- How was the tunic exhibit installed within the museum?
- What workflow process can be used to obtain a list of all tunics?
- What is the global timeline for Inca tunics across all museums?

These questions can be answered through dynamic models of the sort employed in the field of simulation. We will cover the example of dynamic models, but first approach the study of the tunic with a concept map (Novak and Gowin 1984). The concept map is a directed graph of concepts linked by relations. For example, “Inca is a *type_of* culture” and the tunic is *processed_with* a loom, with two types of loom indicated: upright and backstrap. The concept map is a type of semantic model (Sowa 1983). A concept map of the tunic is depicted in Figure 2.

Figure 2: Concept Map of Knowledge about the Inca Tunic



Source of Images: tunic image is from the public DMA digital media collection. Map in the upper left is from Wikimedia Commons: public domain. Remaining images from Shutterstock, Inc., standard license.

The next step in seeing the tunic through the lens of systems thinking is to map out the dynamic relations. We do this by focusing on verb-based relations in English. The diagram in Figure 3 represents a finite state machine (Fishwick 1995), as it is termed in computer science (FSM 2016). Each state has a participle verb form indicating state. For example, to craft a tunic, we begin by shearing an animal from the camelid family, such as an alpaca. Thus, the system that indicates how the tunic is made can be seen as a sequence of activities (i.e., states) of different people in a sequence-based pipeline.

Figure 3: Four Connected States Comprising a finite State Machine (FSM) for the Tunic Process

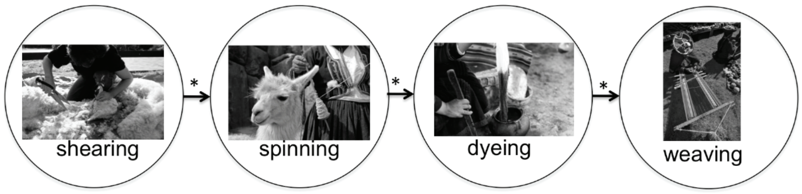


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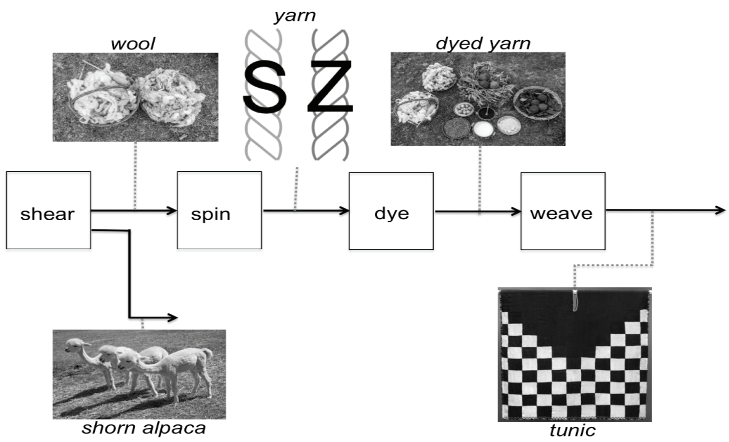
Figure 4 presents the dynamics of making the tunic using a data flow graph. For data flow, information is processed from one functional node (e.g., *spin*) to the next. Starting on the left of Figure 5, an alpaca is sheared. In a more detailed model, there would be an arrow input to "shear," but this is left out for simplifying the diagram. There are two outputs from shear: one going to the wool, which subsequently must be spun, and another representing the alpaca minus the sheared wool: the shorn alpaca. Spinning can be done in one of two directions termed *S ply* versus *Z ply*.

Figure 4: A Data Flow Graph that Represents Material flowing from Left to Right**.** Each Node is a Function or Process, as indicated by a Verb



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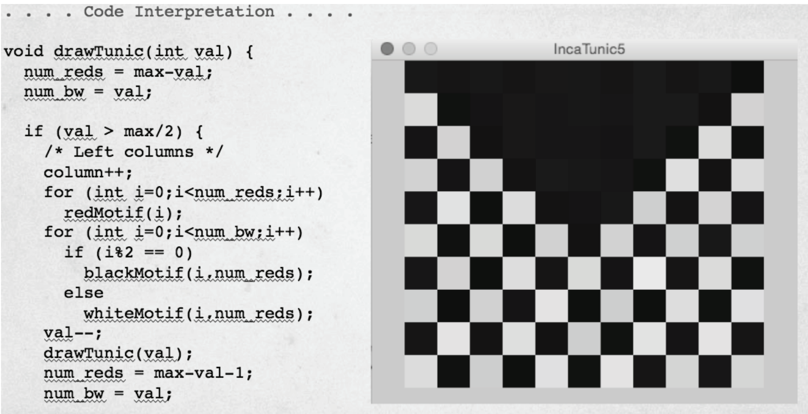
Figures 2 through 4 illustrate three model types, where there is a design effort to ensure that each model component is denoted by text and some graphical cues, such as photographs. This approach to model design is deemed necessary where the visitor is belonging to a general population, rather than coming from a highly technical domain such as engineering.

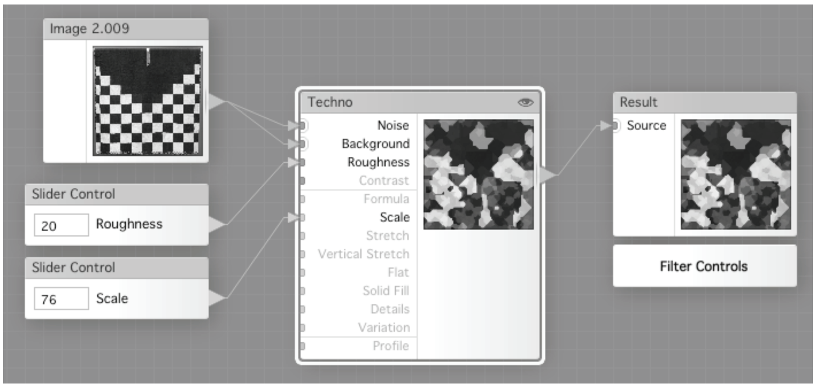
Figure 5 shows how programming can be considered modelling (of a decision procedure). A partial Processing program on the left side indicates a piece of the program, with the synthetic tunic image on the right side obtained from executing the program. The code is a textual model that captures *a computer science type of interpretation* of the original tunic.

Figure 5: A Processing Program Excerpt (left), which Produces an Image similar to the Inca Tunic (right)



Numerous other models are possible for the tunic such as the one in Figure 6 where a data flow model takes the original tunic image on the left and then applies this image, through a left-to-right flow via functional image filters.

Figure 6: A Data Flow Model that Processes Images using Filter Nodes



Program: Filterforge (<https://www.filterforge.com/>) (Filterforge 2016).

4. Discussion

I have met many colleagues with an intense interest in modelling. Examples of related research by some of these colleagues are defined by the shared concern for the possibilities of modelling, and how models compare, contrast and differ between science and engineering versus the humanities (Bod 2016; Ciula and Marras 2016; McCarty 2004). I found that, collectively speaking, we had more in common than we had differences with respect to modelling. Even though the phrase “modelling and simulation” is commonly employed in science and engineering, it was useful to separate out modelling from simulation since modelling represents a broader enterprise that cuts across all disciplines.

Giorgio Fotia was the respondent in my talk and he surfaced many interesting issues. Fotia’s focus on modelling was related to modelling within the biological sciences. Most of Fotia’s models were “mathematical models,” meaning that the models were represented using mathematical notation. I discussed how this type of notation was one type of model notation with others coming from areas such as discrete event modelling, conceptual modelling, and modelling text. Many models are represented in diagrammatic rather than symbolic form. Figures 2 through 6 exemplify this difference.

My most important moment of learning dealt with the need for those engaged in the practice of modelling to spend more effort in dealing with model-to-model translation. Take mathematical models as an example. When a scientist uses a mathematical model, they rarely think in terms of the symbols. Instead, the symbols aggregate to correspond with laws of conservation. It is more important to see equations based on Newton’s laws with natural language such as “force from ball impact” or “torque from wooden wheel.” The symbols are efficient and economic, but modellers see beyond them to natural language forms, common to the language arts. Therefore, future computer interfaces that begin with natural language, or that allow these symbols to coexist with the mathematical symbols would be useful when reasoning across disciplines.

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